LARGE-SCALE PEAT FEED PREPARATION

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Introduction

In 1980 the Institute of Gas Technology (IGT) installed large-scale drying, grinding, screening and transport equipment for processing of Minnesota peat in an existing pilot plant designed to produce substitute natural gas (1). The facility, located at IGT's Energy Development Center in Chicago, is capable of drying 16 tons per hour of as-received-peat (60-75 wt % moisture content) to a controlled product-moisture-content ranging between 5 and 50 wt %. Subsequent screening and grinding operations produce a -20+80 USS mesh size product for injection into the fluidized bed gasifier. See Figure 1.

Since this was the first large-scale attempt in this country to prepare and transport peat at moisture levels as low as 5 wt %, two major questions were asked: 1) What procedures and what type of equipment would be required to process, transport and store peat, and 2) what affect would these operations have on the physical and chemical characteristics of the peat?

The successful operation of the peat feed preparation system (2000 tons of wet peat processed) provided these answers. The results of these efforts are summarized in this paper.

Design Conditions

Since the selection of appropriate equipment and the definition of handling precautions were prerequisites of the design phase, IGT's process development group concentrated its initial efforts in this area. The selection of drying equipment, capable of providing a wide range of product moisture contents, received the highest priority. One of the most important selection criteria was the ability to moderate temperatures sufficiently such that the chemical composition of the peat would not be affected even when dried to 5 wt % moisture. Both foreign and U.S. companies were contacted and all commercially available equipment evaluated. The types of dryers considered included: rotary drum dryers, flash dryers, and fluidized-bed dryers. Grinding and screening equipment was also evaluated. Design considerations included the ability to handle a range of moisture contents, ability to handle fibrous and woody material, and minimization of fines production.

In order to identify proper handling precautions, IGT commissioned the Technical Research Center of Finland to survey available data in the Scandinavian, Russian, and German literature and to provide summary reports of their findings(2,3). These reports did indicate that additional precautions must be taken as peat moisture contents are lowered. Existing data indicated that:

- o When the moisture content is 35-40%, peat dust is only slightly susceptible to explosion and when the moisture content is 40-50%, the dust is not explosible under ordinary conditions.
- o As the moisture content decreases, the minimum explosible concentration of peat dust decreases.
- o As the moisture content decreases, the maximum pressure and the maximum rate of pressure rise of the peat dust explosion increase.

- As the moisture content decreases, the minimum ignition energy of the peat dust cloud also decreases.

Commercial experience also provided the following recommendations:

- Operate continuous rather than batch processes.
- Isolate high risk equipment.
- Design mass flow systems for small quantities.
- Locate equipment outdoors.

As a result of these investigations and recommendations, a final process configuration was selected for the peat preparation facility.

Process Description

Figure 2 presents the equipment selected for the peat feed preparation facility. Peat is received untreated from the bog and stored at the site in an outdoor storage area. In order to facilitate handling, the peat is first dried and then screened and ground to the proper size consistency. A triple-pass rotary drum dryer was chosen to provide the necessary flexibility in drying capacity. See Figure 3. Peat is, for the most part, conveyed by the hot flue gases through the multiple-pass system. Large particles, which require longer residence times to achieve the same moisture reduction, are hindered sufficiently to obtain the necessary drying time. A 50 million Btu/h natural gas burner provides a hot, co-current air stream with a maximum initial contact temperature of 1200°F. Moisture content of the peat is controlled by the exit air temperature, which typically ranged between 110° and 260°F for moisture contents between 40 and 5 wt %.

Since the dryer system presents the highest risk for dust ignition, isolation was provided by rotary valve seals. In addition, a steam quenching system and relief doors were provided as additional safeguards. Sealed screw conveyors and a bucket elevator were used to transport the dried peat to the screening and drying system. Conventional screeners and a hammer mill were chosen to size the product. An overall view of the peat preparation facility is shown in Figure 4.

Product peat was then delivered to either a high-pressure, lockhopper feed injector (4), slurry preparation or 400-ton storage silos. All storage bins were purged with nitrogen to provide an inert atmosphere and were monitored for oxygen content. These design considerations have resulted in the controlled production of peat containing moisture contents as low as 5 wt % in a reliable and safe manner.

Test Results

Once operation of the facility was begun, data were collected to determine the effects on the physical and chemical properties of the peat during the various processing steps. Minnesota peat, obtained from the Northern Peat Company, Grand Rapids, Minnesota, exhibited a remarkable uniformity in chemical composition and moisture content. Average values for size distribution and chemical composition and the standard deviation for a sample size of seven are given in Tables 1 and 2. Of greatest concern was the occasional lacing of the 'raw' peat with semi-decomposed tree roots and stumps, as well as gravel picked up during harvesting operations in the field. These materials were removed by a 2x2 stationary screen.

One of the main design considerations for the selection of the drying system was to minimize overheating and chemical degradation of the peat particle during drying. Samples of peat exiting the dryer were routinely taken and analyzed for chemical composition. Table 3 compares values at moisture levels of 5.3, 10.1, 16.0, and 22.0 wt % against those of raw peat containing 68.9 wt % moisture. It can be seen that no significant change in chemical composition occurs during the drying operation.

Size distribution changes do occur as peat is dried. Table 4 and Figure 5 provide a comparison of sieve analyses for various moisture levels exiting the dryer. Sufficient size reduction occurs to warrant screening prior to grinding to a -20+80 USS product size.

Another issue of interest is the homogeneity of the moisture level for the peat exiting the drying system. Figure 6 indicates the variation in moisture content as a function of particle size for various peat samples exhibiting average moisture levels of 30, 36, and 42 wt %. This is particularly important in cases where downstream processing would tend to encourage segregation. For instance, screening area requirements can be affected by both the feed rate, particle shape and moisture content of the peat.

Similar concerns were raised about the chemical composition variation as a function of particle size. Data taken of the product, fines and oversize streams from the screening operation (Table 5) do not indicate any significant difference in chemical composition.

Summary

Data collected during an operating period which processed over 2000 tons of as-received Minnesota peat have shown that peat can be dried, screened and finely ground in a reliable and safe manner. Moisture reduction to as low as 5 wt % can be obtained in properly designed systems without chemical degradation of the product. Some reduction in the size distribution of the Minnesota peat did occur during the drying operation. In addition, the moisture content of the product is not completely homogeneous. Moisture content does vary with particle size, however, chemical composition does not vary significantly with particle size. These findings were subsequently used in evaluating process and equipment requirements for downstream operations in the gasification pilot plant. Segregation, for instance, of the product peat was discouraged in order to ensure uniform levels of moisture in the feed to the gasifier.

Acknowledgement

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4. Wohadlo, S.J., Biljetina, R., Laurens, R.M., and Bachta, R., "Solids Flow Control and Measurement in the Peatgas Pilot Plant Program", paper presented at the Sixth Annual 1982 Symposium on Instrumentation and Control for Fossil Energy Processes, Houston, Texas, June 7-9, 1982.

Table 1. AVERAGE SIZE DISTRIBUTION FOR AS-RECEIVED MINNESOTA PEAT

Screen Analysis, U.S.S., wt %			Standard Deviation
+ 10		42.3	4.6
+ 20		25.6	2.1
+ 30		9.2	1.1
+ 60		12.9	3.9
+ 80		3.7	1.0
+100		2.1	0.8
+200		1.2	0.4
+230		2.1	0.5
PAN		0.9	0.6
	TOTAL	100.0	

Table 2. AVERAGE CHEMICAL COMPOSITION FOR AS-RECEIVED MINNESOTA PEAT

Chemical Analysis, wt %			Standard Deviation
Proximate (Dry)			
Volatile Matter		59.4	1.1
Fixed Carbon		23.2	1.3
Ash		17.4	1.2
	TOTAL	100.0	
Moisture		68.9	1.0
Ultimate (Dry)			
Carbon		48.3	1.3
Hydrogen		5.0	0.2
Sulfur		0.3	0.05
Nitrogen		2.1	0.1
Oxygen		26.9	0.7
Ash		17.4	2.2
	TOTAL	100.0	

Table 3. COMPARISON OF PEAT CHEMICAL COMPOSITION AT VARIOUS MOISTURE LEVELS

Description	RAW* PEAT	SDEV**	DRIED PEAT	SDEV	DRIED PEAT	SDEV	DRIED PEAT	SDEV	DRIED PEAT	SDEV
Moisture, wt %	68.9	1.0	5.3	0.2	10.1	1.4	16.0	1.1	22.0	2.4
Proximate Analysis (Dry), wt %										
Volatile Matter	59.4	1.1	59.1	1.1	59.1	1.4	59.6	1.1	59.6	0.8
Fixed Carbon	23.2	1.3	23.6	0.7	23.5	1.2	23.5	1.1	23.6	1.0
Ash	17.4	1.2	17.3	1.1	17.4	1.8	16.9	0.7	16.8	0.6
TOTAL	100.0		100.0		100.0		100.0		100.0	
Ultimate Analysis (Dry), wt %										
Carbon	48.3	1.3	48.2	0.6	48.4	0.8	48.7	0.5	48.2	0.4
Hydrogen	5.0	0.2	5.0	0.1	5.0	0.1	5.0	0.1	5.1	0.1
Sulfur	0.3	0.05	0.3	0.08	0.3	0.07	0.3	0.08	0.2	0.05
Nitrogen	2.1	0.1	2.2	0.1	2.2	0.1	2.3	0.2	2.2	0.1
Oxygen	26.9	0.7	27.0	0.5	26.7	0.9	26.8	0.5	27.5	0.3
Ash	17.4	2.2	17.3	1.1	17.4	1.8	16.9	0.7	16.8	0.6
TOTAL	100.0		100.0		100.0		100.0		100.0	

* As-received from bog.

** SDEV = Standard Deviation

Table 4. COMPARISON OF PEAT SIZE DISTRIBUTION AT VARIOUS MOISTURE LEVELS

Description	RAW PEAT	SDEV*	DRIED PEAT	SDEV	DRIED PEAT	SDEV	DRIED PEAT	SDEV	DRIED PEAT	SDEV
Moisture, wt %	68.9	1.0	5.3	0.2	10.1	1.4	16.0	1.1	22.0	2.4
Screen Analysis, U.S.S., wt %										
+ 10	42.3	4.6	9.2	1.8	13.7	5.4	12.7	1.4	11.9	3.0
+ 20	25.6	2.1	27.4	5.3	27.2	2.9	33.8	5.0	29.9	3.0
+ 30	9.2	1.1	15.4	2.9	13.6	1.3	16.7	0.8	14.0	2.7
+ 40	--	--	13.2	3.8	12.1	2.9	8.8	4.4	11.7	0.7
+ 60	12.9	3.9	18.5	3.8	16.6	3.3	16.3	3.8	16.0	3.1
+ 80	3.7	1.0	4.7	1.3	5.4	1.9	3.9	1.1	5.7	0.3
+100	2.1	0.8	3.1	0.7	3.8	1.9	2.6	1.0	2.8	0.2
+200	1.2	0.4	4.6	1.7	4.0	0.9	1.9	1.2	3.7	1.6
+230	2.1	0.5	1.3	0.9	1.3	1.7	1.5	0.9	1.5	0.9
PAN	0.9	0.6	2.6	0.6	2.3	0.3	1.8	0.5	2.8	0.9
TOTAL	100.0		100.0		100.0		100.0		100.0	

* SDEV = Standard Deviation

Table 5. COMPARISON OF CHEMICAL COMPOSITION FOR PEAT OF DIFFERENT SIZE FRACTIONS

Description	DRYER DISCH.	FINES	OVER SIZE	SIZED PRODUCT
Mass Fraction, wt % (U.S. Sieve)				
+20	30.1	0.1	93.5	3.5
-20 to +80	53.0	7.6	6.1	94.0
-80	16.9	92.3	0.4	2.5
Proximate Analysis, wt %				
Volatile Matter	59.4	57.0	60.2	58.7
Fixed Carbon	25.0	23.0	24.3	24.6
Ash	15.6	20.0	15.5	15.7
TOTAL	100.0	100.0	100.0	100.0
Ultimate Analysis, wt %				
Carbon	49.3	46.7	49.3	49.2
Hydrogen	5.1	4.9	5.1	5.2
Sulfur	0.4	0.3	0.3	0.3
Nitrogen	2.2	2.2	2.1	2.2
Oxygen	27.4	25.9	27.7	27.4
Ash	15.6	20.0	15.5	15.7
TOTAL	100.0	100.0	100.0	100.0
Moisture, wt %	7.1	7.9	11.4	7.7
Bulk Density, lb/ft^3	27.8	30.1	26.6	26.8

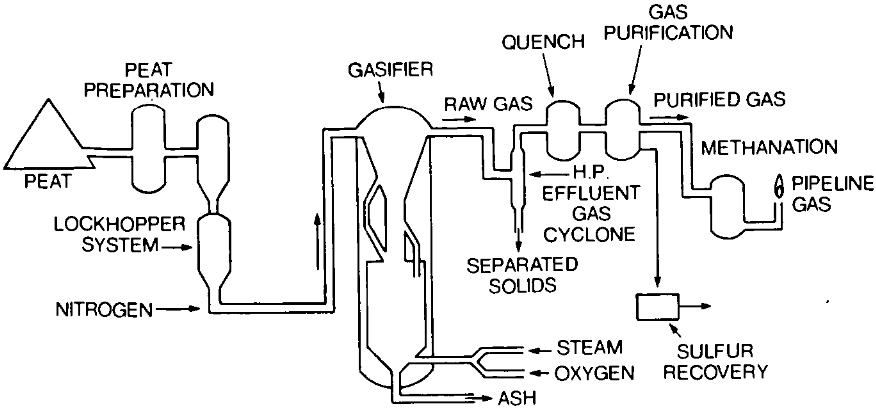

Figure 1. PEATGAS PILOT PLANT FACILITY

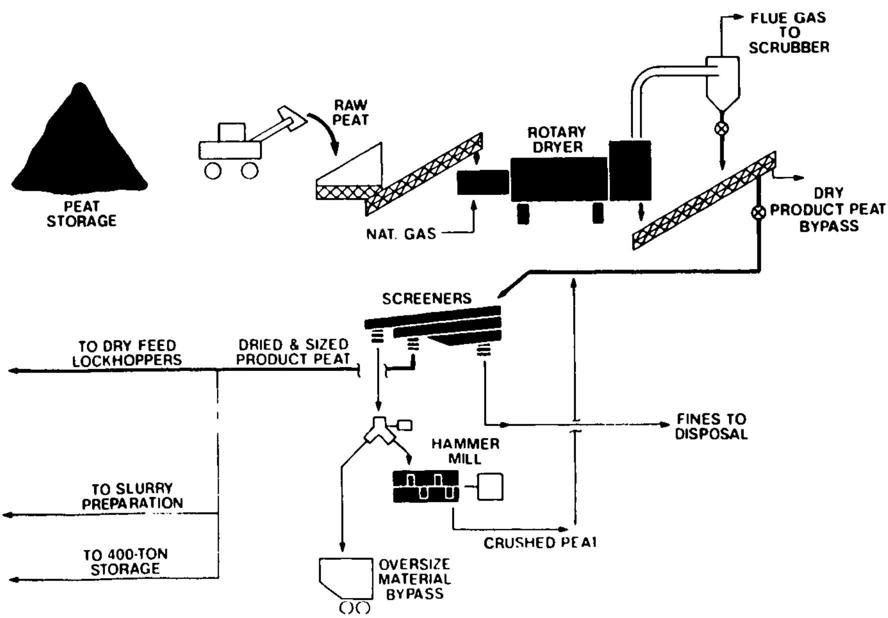

Figure 2. PEAT PREPARATION

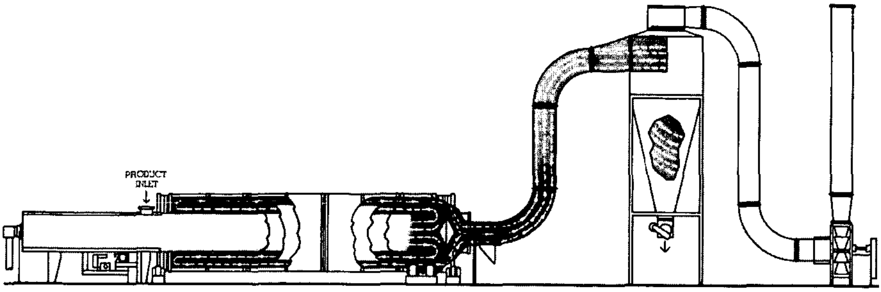

Figure 3. TRIPLE-PASS DRYER SELECTED FOR THE PEAT DRYING SYSTEM

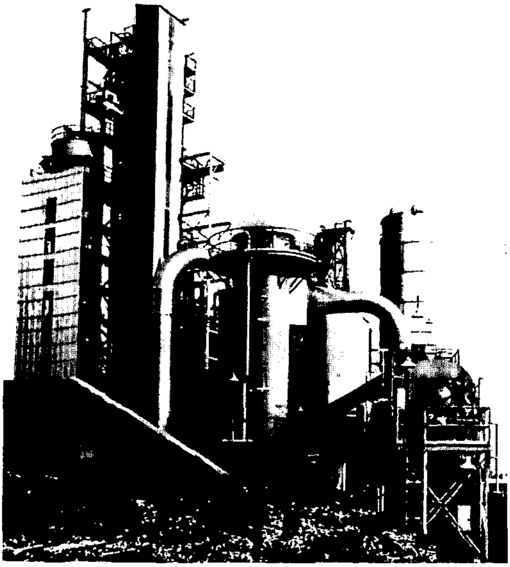

Figure 4. DRYING SYSTEM IN OPERATION

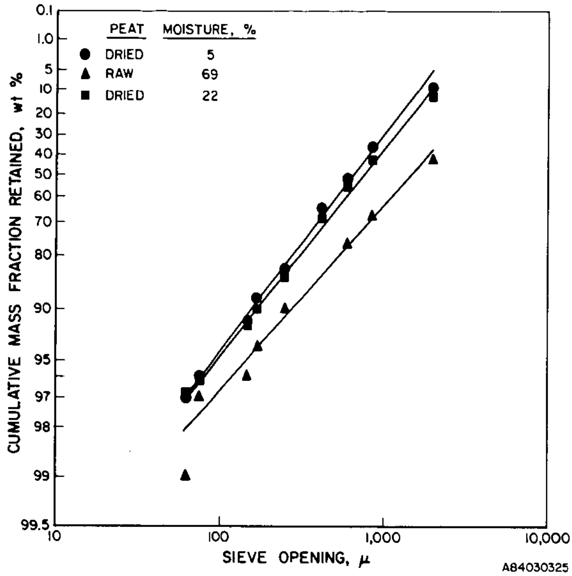

Figure 5. GRAPHICAL REPRESENTATION OF THE SHIFT IN SIZE DISTRIBUTION OF DRIED PEAT

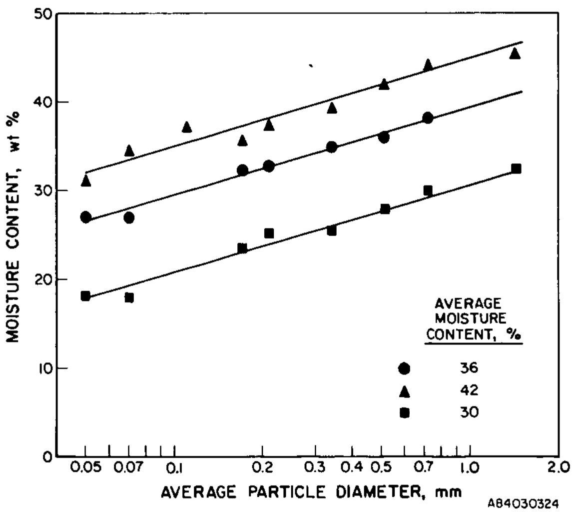

Figure 6. PEAT MOISTURE CONTENT AS A FUNCTION OF PARTICLE SIZE FOR SAMPLES EXHIBITING AN AVERAGE MOISTURE CONTENT OF 42, 36 AND 30 wt %